PIDA
and its application to Kaon Analysis

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Intro to PIDA

PID module developed for ArgoNueT, living in LArSoft

Uses expected power-law dependence of dE/dx for **Stopping particles** as described by the Bethe-Bloch equation. Can be approximated using:

$$(dE/dx)_{hyp} = A\, R^{b}$$

Where R is residual range and A and b are parameterization variables.

Setting b = -0.42, the module finds A by taking the average of all spacepoints in the track using:

$$A_i = (dE/dx)_{calo,i} R_i^{0.42}$$

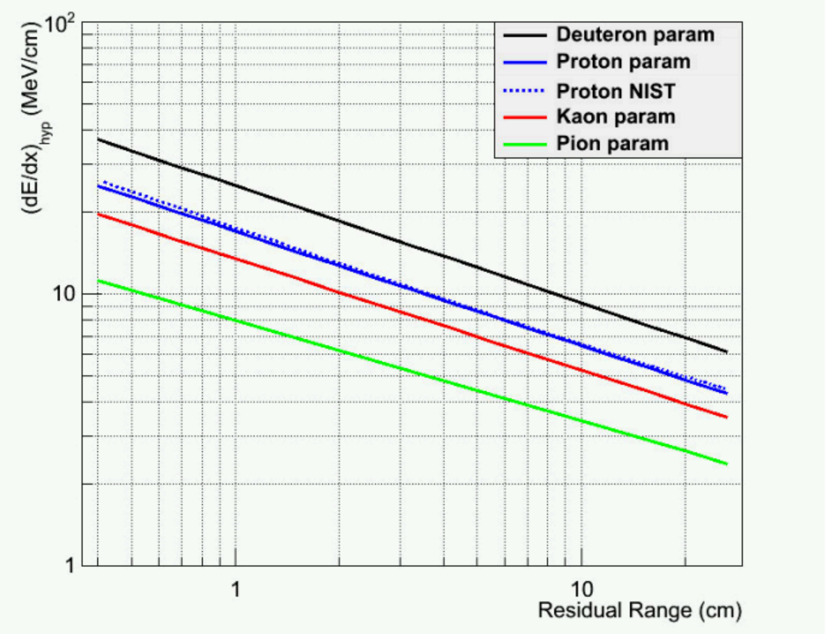
This number A is unique for a stopped particle:

Particle	A MeV/cm^{1-b}	b
pion	8	-0.37
kaon	14	-0.41
proton	17	-0.42
deuteron	25	-0.43

Error from fixed b is negligible compared to ionization fluctuations.

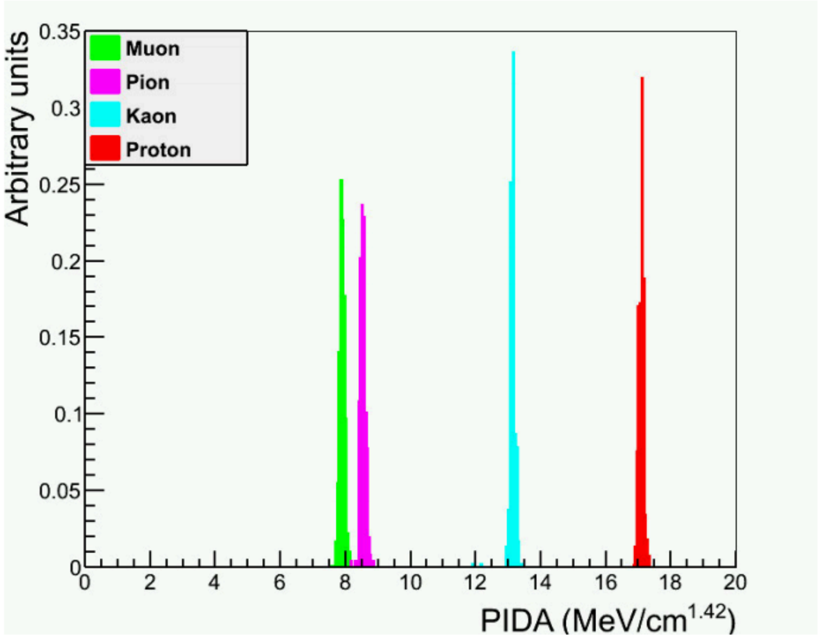
PIDA MC Performance

Parameterization of each particle according to table on last page.



Blue dotted line represents error compared against the true Beta-Bloche

Result of PIDA module on samples of MC stopping particles

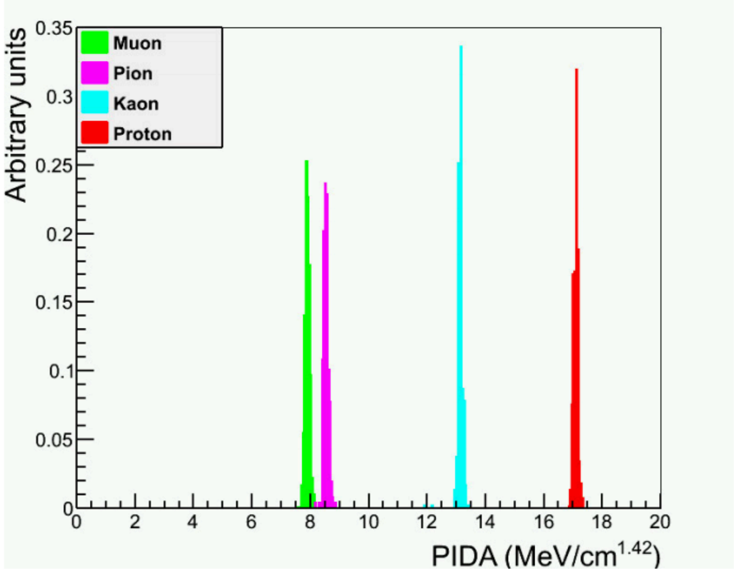


See arXiv:1306.1712 for more info.

Application to Kaons

Proton contamination is apparently significant in current Kaon sample.

Protons and Kaons frequently stop in the TPC,
making PIDA potentially useful to tag and cut Protons.



However not All Kaons / Protons Stop

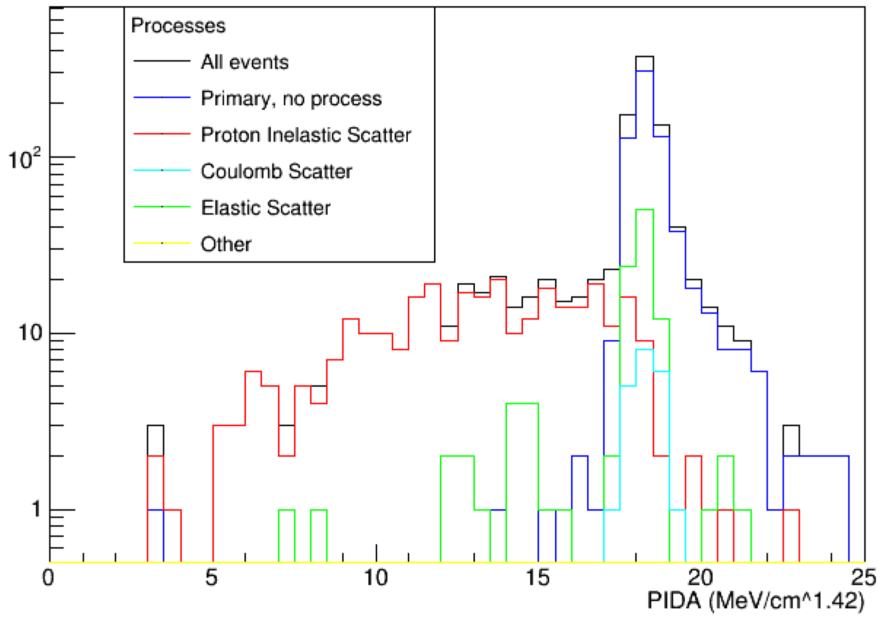
To apply the PIDA as a filter, need to investigate how it performs on particles that are not exclusively stopping

Since interactions end the primary track before it deposits all of its energy, calculates of PIDA of an interacting particle is expected to be Lower than its Stopping value.

PIDA has the added benefit that it can be used to tag Stopping Kaons,
useful for when it comes time to calculate cross section.

Proton MC PIDA

1800 events, flat distribution of Pz between 500 and 1000 MeV



After cuts:

Process	Events
Total	1121
Primary	682
Proton In.	309
Coul. Scatter	21
Elastic Scatter	109
Other	0

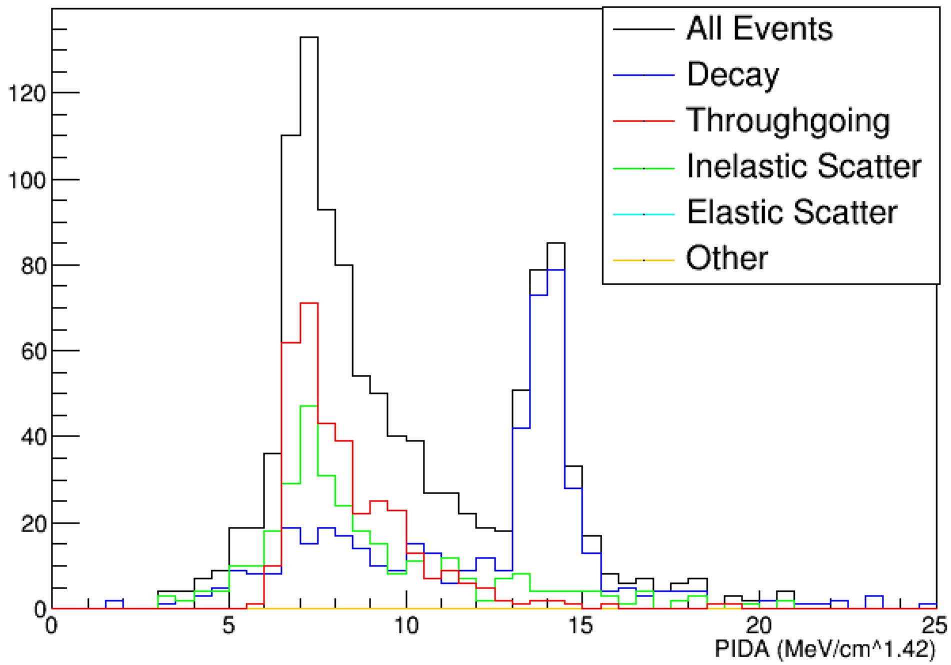
- Elastic/coulomb scatter lose little energy and most are Not reconstructed as two tracks
- Proton inelastic scatter results in large energy lose or multiple track reconstruction.

Looking by eye show that it is a mix of the two.

A cut at 15 MeV/cm^1.42 removes 80.9 % of the protons

Kaon MC PIDA

1800 events, flat distribution of Pz between 500 and 1000 MeV



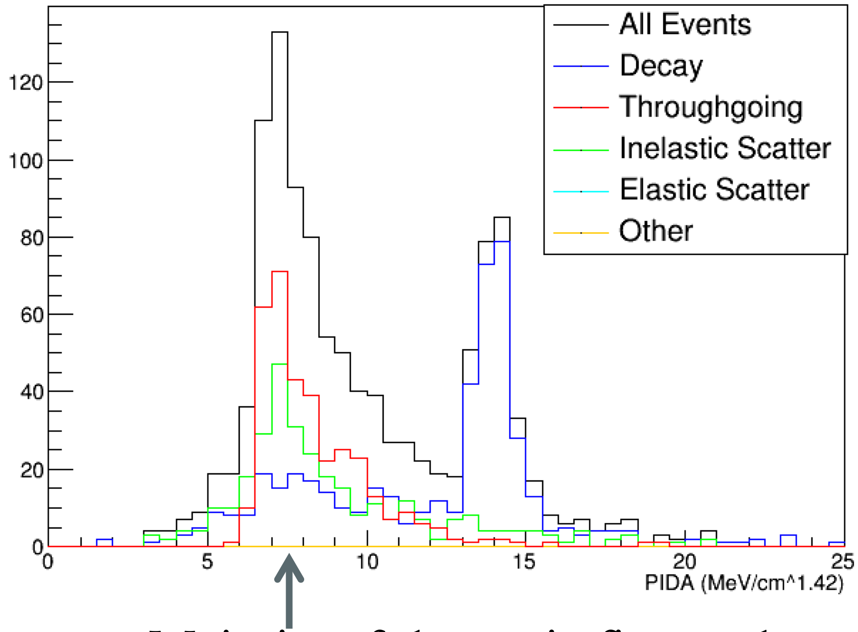
After cuts:

Process	Events
Total	1138
Decay	479
Throughgoing	347
InElastic Scat.	312
Elastic Scatter	0
Other	0

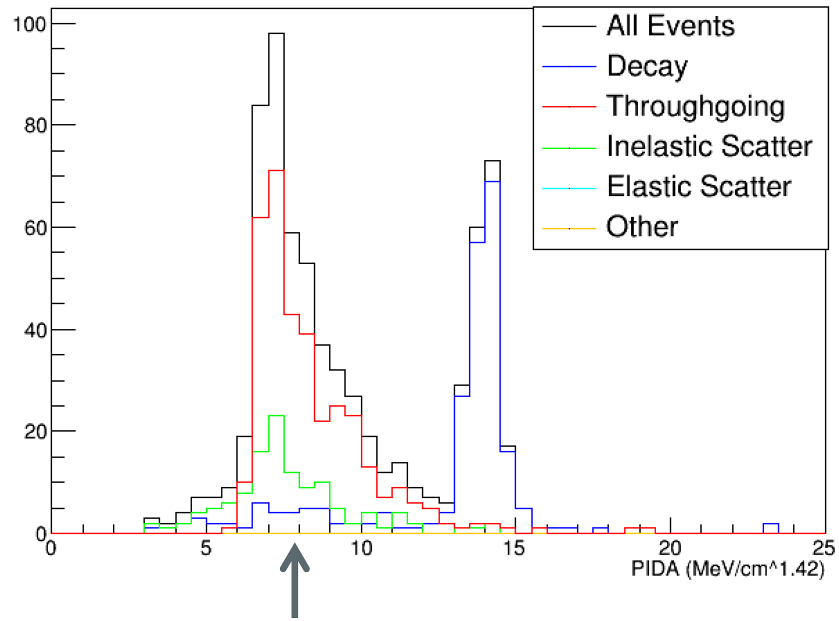
- Many decays occur after stopping, making the peak at ~14
- Inelastic scatters are in the first peak, meaning they either lose much energy in the scatter or are reconstructed as two tracks.
- Decays present in first peak may be the sign of scatters that Geant4 does not count but our reconstruction makes two tracks.

Kaon Decays in First PIDA Peak

Normal Cuts Only:



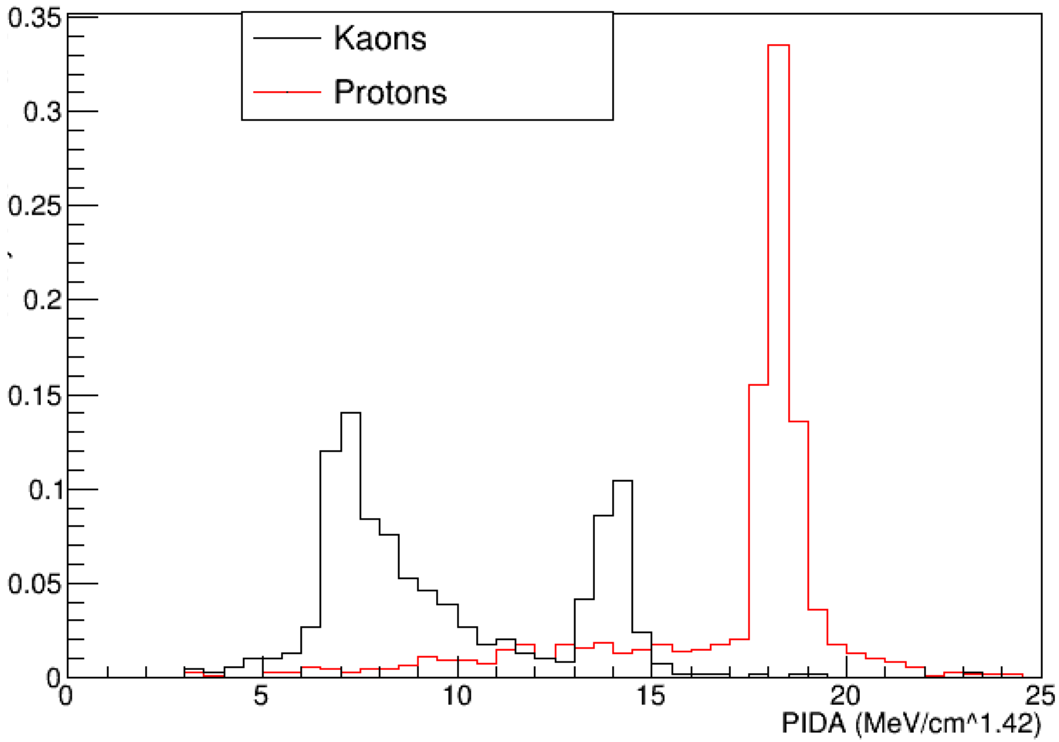
Truth Primary Track End Point Within 1cm of Reco Track:



Majority of decays in first peak removed with this cut, evidence that they are a reconstructed scatter that Geant4 does not label as a process.

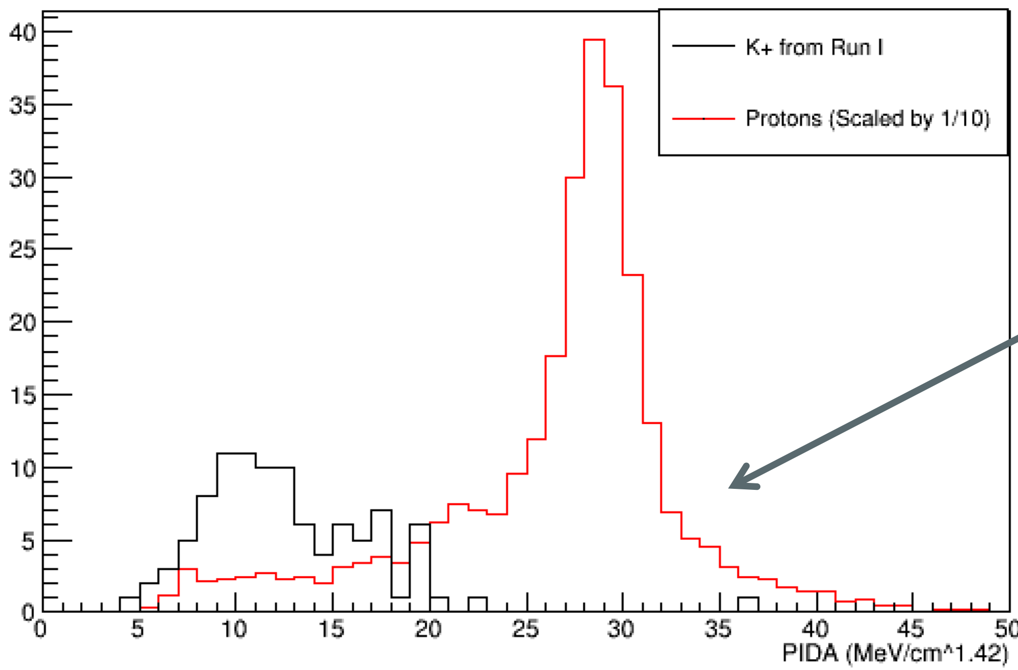
Note that a number of inelastic scatters are also removed from this cut. Why?

MC Proton and Kaon PIDA



A cut at 15 MeV/cm^1.42 removes 80.9 % of protons

PIDA on Data



Kaon Sample: 100 events
Proton sample: 2814 events

Note a change in scale.
MC Proton Peak : ~19
Data Proton Peak: ~28
Should just be a scaling factor dependent upon the calorimetric reconstruction

Low Statistics in K+ sample makes comparison difficult.

Potential solutions include getting better statistics from Run II or hand select protons from Run I K+ sample to see their PIDA values

Modules and Git

feature/v05_12_00_KaonAna

It may be best to freeze our LArIATSoft / LArSoft build now so that updates do not slow analysis down.

LArIATFilterModule/KaonFilter_module.cc
- Only beamline filters, including aerogel and mass cuts

LArIATFilterModule/KaonTPCFilter_module.cc
- Only on TPC related information. Currently redundant due to PIDA filter

LArIATFilterModule/PIDAFilter_module.cc
- A general purpose filter that cuts on PIDA based on upper and lower bounds passed into the module via fcl file parameters.

Backup

Cuts on MC Samples

Proton Reduction Table	
Sample Size	1800
Primary	1311
Early Z Position Track	1225
MCTrackMatch	1197
Passing Alpha	1121

KaonReduction Table	
Sample Size	1800
Primary	1468
Early Z Position Track	1342
MCTrackMatch	1214
Passing Alpha	1138

- Primary track enters TPC
- Reco. Track begins < 2.0 cm into TPC
- # Upstream TPC tracks <= 4
- Matched Geant4 and Reco. Tracks within:

$$-2.0 < \text{DeltaX} < 6.0$$
$$-3.0 < \text{DeltaY} < 6.0$$
$$\text{Alpha} < 10.0$$